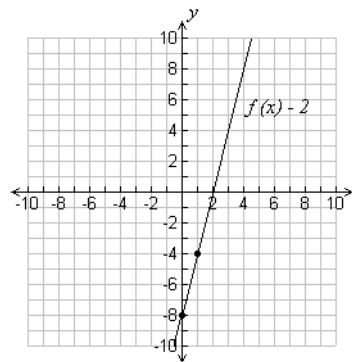


Solutions – Chapter 3

Section 3.1

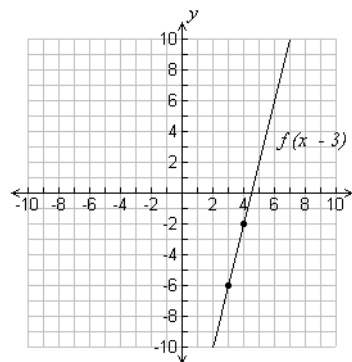
1. $f(x) - 2$ Vertical shift down 2 units
 $(x, y) \rightarrow (x, y - 2)$
 $(0, -6) \rightarrow (0, -8)$
 $(1, -2) \rightarrow (1, -4)$

$$\begin{aligned}y &= f(x) - 2 \\y &= 4x - 6 - 2 \\&= 4x - 8\end{aligned}$$



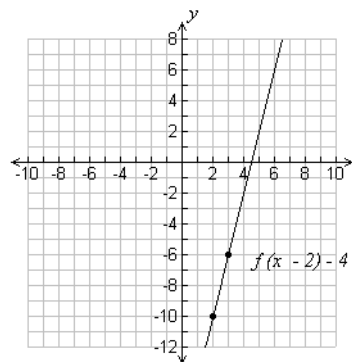
3. $f(x - 3)$ Horizontal shift right 3 units
 $(x, y) \rightarrow (x + 3, y)$
 $(0, -6) \rightarrow (3, -6)$
 $(1, -2) \rightarrow (4, -2)$

$$\begin{aligned}y &= f(x - 3) \\y &= 4(x - 3) - 6 \\&= 4x - 12 - 6 \\&= 4x - 18\end{aligned}$$



5. $f(x - 2) - 4$ Horizontal shift right 2 units, vertical shift down 4 units
 $(x, y) \rightarrow (x + 2, y - 4)$
 $(0, -6) \rightarrow (2, -10)$
 $(1, -2) \rightarrow (3, -6)$

$$\begin{aligned}y &= f(x - 2) - 4 \\y &= (4(x - 2) - 6) - 4 \\&= 4x - 8 - 10 \\&= 4x - 18\end{aligned}$$



23. $f(x) + 2$ when $x = -3$
From the table $f(-3) = 10$, so $10 + 2 = 12$
Therefore, $f(x) + 2$ is 12

25. $f(x-2)$ when $x=0$

Simplify first $f(0-2) \rightarrow f(-2)$

From the table $f(-2) = 7$

Therefore, $f(x-2)$ is 7

27. $f(x+1)-9$ when $x=-2$

Simplify first $f(-2+1)-9$ becomes $f(-1)-9$

From the table $f(-1) = 2$, so $2 - 9 = -7$

Therefore, $f(x+1)-9$ is -7

47.

x	$f(x)$	$f(x)+6$ (up 6)	$f(x+2)$ (left 2)	$f(x-1)$ (right 1)	$f(x-2)+4$ (right 2, up 4)
-5	10.75	16.75	4	unknown	unknown
-4	6.5	12.5	2	10.75	unknown
-3	4	10	0	6.5	14.75
-2	2	8	-1.5	4	10.5
-1	0	6	-4	2	8
0	-1.5	4.5	-6.25	0	6
1	-4	2	-8.5	-1.5	4
2	-6.25	-0.25	unknown	-4	2.5
3	-8.5	-2.5	unknown	-6.25	0

48. $A(x) = (x+4)^2$ (left 4 units) is graph E

49. $C(x) = (x-4)^2$ (right 4 units) is graph D

50. $C(x) = (x-2)^2 + 4$ (right 2 units, up 4 units) is graph F

67. a) The function would represent the number of golf facilities in the U.S. as a function of years since 1975.

$$f(t) = G(t-5)$$

b) The function would represent the number of golf facilities in the U.S. as a function of years since 1990.

$$f(t) = G(t+10)$$

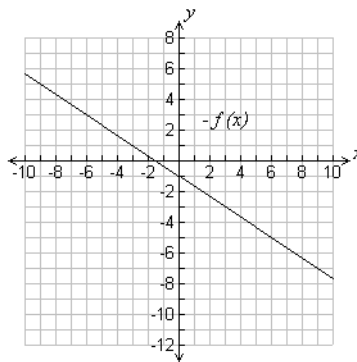
c) The function would represent the additional number of golf facilities built in the U.S. after 1980 as a function of years since 1980.

$$f(t) = G(t) - 12000$$

Section 3.2

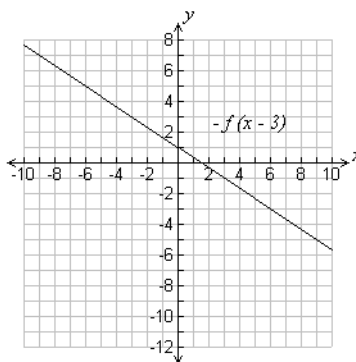
1. $f(x) = \frac{2}{3}x + 1$

$$\begin{aligned} -f(x) &= -\left(\frac{2}{3}x + 1\right) \\ &= -\frac{2}{3}x - 1 \end{aligned}$$



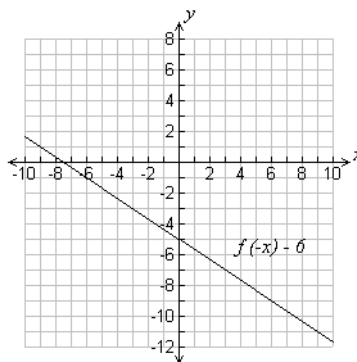
3. $f(x) = \frac{2}{3}x + 1$

$$\begin{aligned} -f(x-3) &= -\left(\frac{2}{3}(x-3) + 1\right) \\ &= -\left(\frac{2}{3}x - 2 + 1\right) \\ &= -\left(\frac{2}{3}x - 1\right) \\ &= -\frac{2}{3}x + 1 \end{aligned}$$



4. $f(x) = \frac{2}{3}x + 1$

$$\begin{aligned} f(-x) - 6 &= \left(\frac{2}{3}(-x) + 1\right) - 6 \\ &= -\frac{2}{3}x + 1 - 6 \\ &= -\frac{2}{3}x - 5 \end{aligned}$$



19. $-f(x)$ when $x = 4$

From the table $f(4) = -25$, so $-f(x) = 25$

20. $-f(x)$ when $x = -6$

From the table $f(-6) = 20$, so $-f(x) = -20$

21. $f(-x)$ when $x = 2$

Input 2 gives $f(-2)$

From the table $f(-2) = 5$

32. $f(x) = 25$ occurs when $x = 4$

33. $f(x) = 13$ occurs when $x = -4$, however the input asks for the opposite of x , therefore $x = 4$.

39. $g(x) = -f(x)$

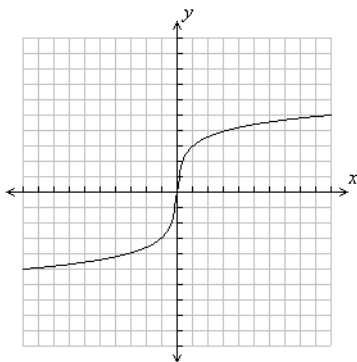
x	$g(x)$
-8	-26
-6	-20
-4	-13
-2	-5
0	4
2	14
4	25
6	37
8	50

40. $h(x) = f(-x) - 2$

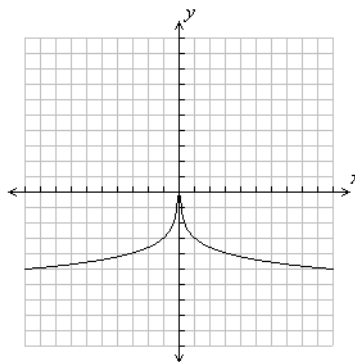
Hint: use $(x, y) \rightarrow (-x, y - 2)$ to find points, then place in table in ascending order

x	$g(x)$
-8	-52
-6	-39
-4	-27
-2	-16
0	-6
2	3
4	11
6	18
8	24

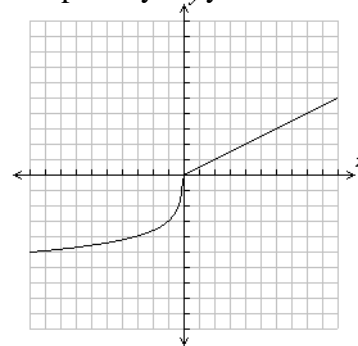
69a.



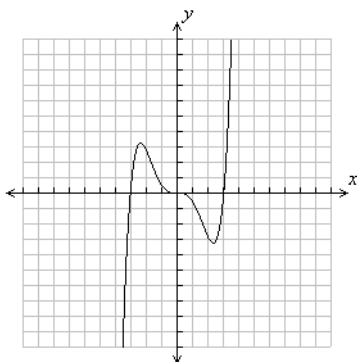
b.



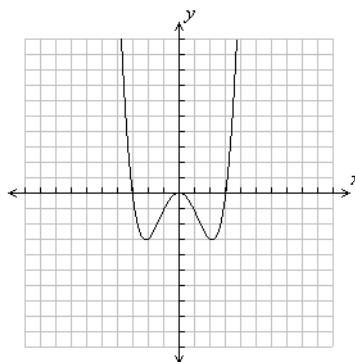
c. Graph may vary



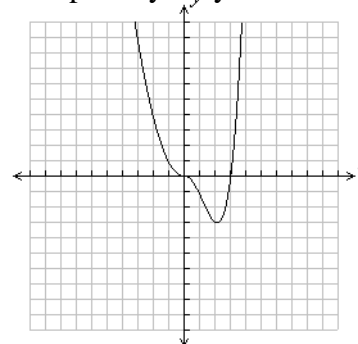
71a.



b.



c. Graph may vary



76. $c(x) = 4x^3 - x$

$$\begin{aligned} c(-x) &= 4(-x)^3 - (-x) \\ &= -4x^3 + x \end{aligned} \quad \text{All terms changed sign, therefore } c(x) \text{ is odd.}$$

77. $d(x) = x^2 - 2x + 1$

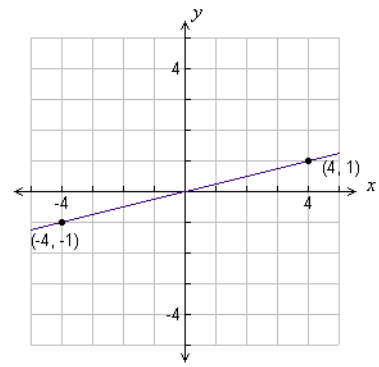
$$\begin{aligned} d(-x) &= (-x)^2 - 2(-x) + 1 \\ &= x^2 + 2x + 1 \end{aligned} \quad \text{Only one term, } 2x, \text{ changed sign, therefore } d(x) \text{ is neither.}$$

Section 3.3

1. $y = \frac{1}{4}f(x)$ Vertical compression of $f(x)$ by a factor of $1/4$

$$y = \frac{1}{4}x$$

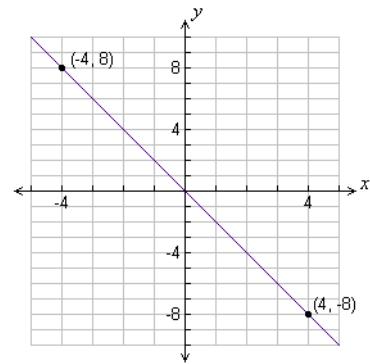
$$\begin{aligned} (x, y) &\rightarrow (x, \tfrac{1}{4}y) \\ (-4, -4) &\rightarrow (-4, -1) \\ (0, 0) &\rightarrow (0, 0) \\ (4, 4) &\rightarrow (4, 1) \end{aligned}$$



2. $y = -2f(x)$ Reflection of $f(x)$ over the x -axis, vertical stretch by a factor of 2

$$y = -2x$$

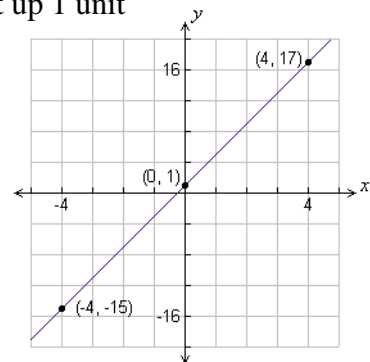
$$\begin{aligned} (x, y) &\rightarrow (x, -2y) \\ (-4, -4) &\rightarrow (-4, 8) \\ (0, 0) &\rightarrow (0, 0) \\ (4, 4) &\rightarrow (4, -8) \end{aligned}$$



3. $y = 4f(x) + 1$ Vertical stretch of $f(x)$ by a factor of 4, shift up 1 unit

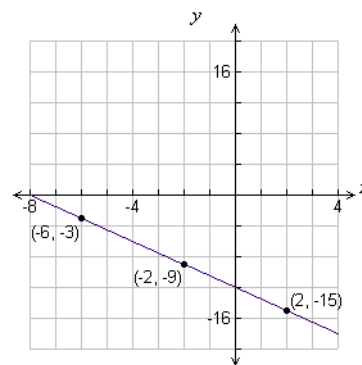
$$y = 4x + 1$$

$$\begin{aligned} (x, y) &\rightarrow (x, 4y + 1) \\ (-4, -4) &\rightarrow (-4, -15) \\ (0, 0) &\rightarrow (0, 1) \\ (4, 4) &\rightarrow (4, 17) \end{aligned}$$



5. $y = 3g(x+2)$ Shift $g(x)$ left 2 units, vertical stretch by a factor of 3

$$\begin{aligned} y &= 3[-0.5(x+2) - 3] & (x, y) &\rightarrow (x-2, 3y) \\ &= 3[-0.5x - 1 - 3] & (-4, -1) &\rightarrow (-6, -3) \\ &= 3[-0.5x - 4] & (0, -3) &\rightarrow (-2, -9) \\ &= -1.5x - 12 & (4, -5) &\rightarrow (2, -15) \end{aligned}$$



20. $g(x)$ is $f(x)$ shifted right 2 units and stretched vertically by a factor of 8.
21. $g(x)$ is $f(x)$ reflected over the x -axis, stretched vertically by a factor of $4/3$, shifted up 3 units.
23. $g(x)$ is $f(x)$ shifted left 5 units, reflected over the x -axis, compressed vertically by a factor of $1/7$.

25. $P(t) = 100V(t)$

$$\begin{aligned} P(t) &= 100(-0.00004785t^3 + 0.02314t^2 - 0.04774t + 1.137) \\ &= -0.004785t^3 + 2.314t^2 - 4.774t + 113.7 \end{aligned}$$

$P(t)$ represents the value of the dollar based on producer prices but measured in 100 dollars increments where t is the number of years since 1980.

34. From the table, $f(4) = -28$,

Multiply by 8

$$8f(4) = 8(-28)$$

The answer is -112 .

$$= -112$$

37. Input $x = -4$ into $f(x+5)$

$f(-4+5)$ simplifies to $f(1)$

From the table, $f(1) = -1$

Multiply by 0.5

$$0.5f(1) = 0.5(-1)$$

The answer is -0.5 .

$$= -0.5$$

46. Begin by getting $f(x)$ alone by dividing by -2

$$-2f(x) = -40$$

$$f(x) = 20$$

From the table we find x when $f(x) = 20$, $x = -1$. The answer is $x = -1$.

47. Begin by getting $f(x)$ alone by dividing by 6

$$6f(x) = 24$$

$$f(x) = -4$$

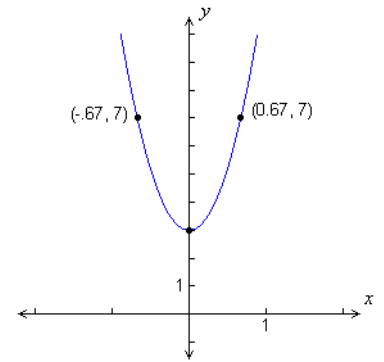
From the table we find x when $f(x) = -4$, $x = 2$. The answer is $x = 2$.

Section 3.4

1. $y = f(3x)$

Horizontal compression of $f(x)$ by a factor of $\frac{1}{3}$

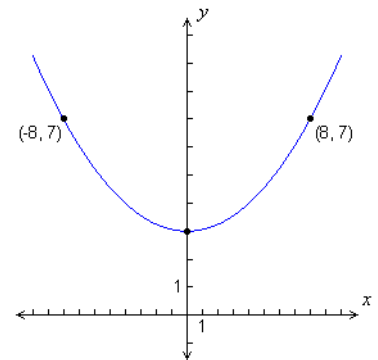
$$(x, y) \rightarrow (\frac{1}{3}x, y)$$



2. $y = f(\frac{1}{4}x)$

Horizontal stretch of $f(x)$ by a factor of 4

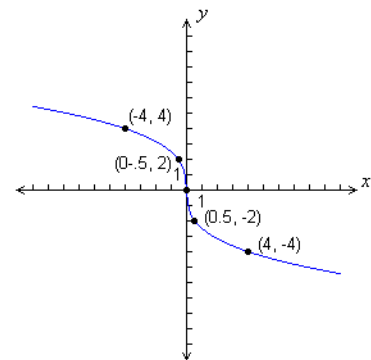
$$(x, y) \rightarrow (4x, y)$$



3. $y = g(-2x)$

Reflection of $g(x)$ over the y-axis, horizontal compression by a factor of $\frac{1}{2}$

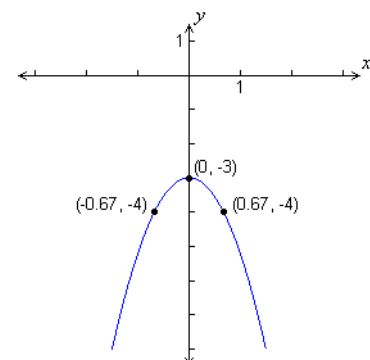
$$(x, y) \rightarrow (-\frac{1}{2}x, y)$$



4. $y = -f(\frac{2}{3}x)$

Reflection of $f(x)$ over the x-axis, horizontal compression by a factor of $\frac{2}{3}$

$$(x, y) \rightarrow (\frac{2}{3}x, -y)$$

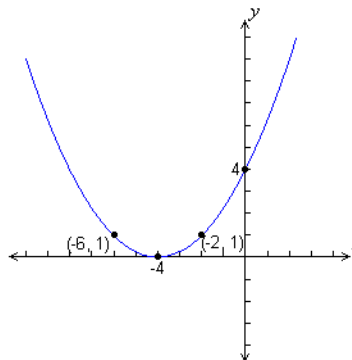


12a. $f(x)$ is shifted left 2 units, and stretched horizontally of by a factor of 2

b. $g(x) = f\left(\frac{1}{2}(x+2)\right)$
 $g(x) = \left(\frac{1}{2}(x+2)\right)^2$

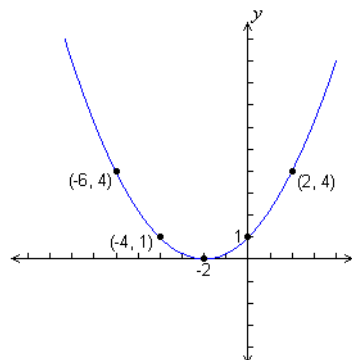
c. Left 2 units, then horizontal stretch by a factor of 2

$(x, y) \rightarrow (2(x-2), y)$
 $(-2, 4) \rightarrow (-8, 4)$
 $(-1, 1) \rightarrow (-6, 1)$
 $(0, 0) \rightarrow (-4, 0)$
 $(1, 1) \rightarrow (-2, 1)$
 $(2, 4) \rightarrow (0, 4)$



Horizontal stretch by a factor of 2, then left 2 units

$(x, y) \rightarrow (2x-2, y)$
 $(-2, 4) \rightarrow (-6, 4)$
 $(-1, 1) \rightarrow (-4, 1)$
 $(0, 0) \rightarrow (-2, 0)$
 $(1, 1) \rightarrow (0, 1)$
 $(2, 4) \rightarrow (2, 4)$



- d. The order of the transformations does matter. From the mapping of the points we see that $2(x-2) \neq 2x-2$. When the order of operations is switched, the horizontal translation becomes left 4 units instead of left 2 units. Following the order of operations, multiplication before addition/subtraction gives the correct graph.

23a. $R(t)$ represents a half-life of 4 hours

Time since taking one dose t (hours)	Amount of Rifampin $R(t)$ (mg)
0	300
4	150
8	75
12	37.5
16	18.75
20	9.375
24	4.688

- b. $R(t)$ represents a half-life of 4 hours and $M(t)$ represents a half-life of 3 hours

Both functions will have the same amounts of Rifampin at different times

$$R(4) = M(3) \text{ because both have an output of 150mg}$$

$$R(8) = M(6) \text{ because both have an output of 75mg}$$

The inputs of $M(t)$ will be $\frac{3}{4}$ the magnitude of the inputs of $R(t)$. A horizontal compression by $\frac{3}{4}$ of $R(t)$ will be written as $M(t) = R(\frac{4}{3}t)$.

28. $f(3x)$ when $x=1$

Input $x=1$ and simplify to get $f(3)$

From the table $f(3) = 24$ The answer is 24.

29. $f(-\frac{2}{3}x)$ when $x=3$

Input $x=3$ and simplify to get $f(-2)$

From the table $f(-2) = 1$ The answer is 1.

46. Skip

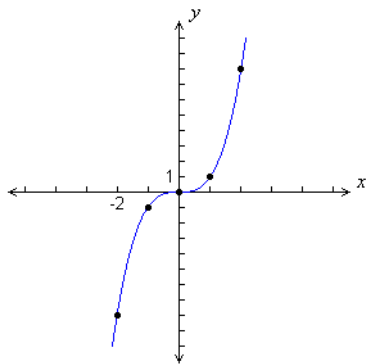
47. Horizontal compression by $\frac{1}{2}$, up 3 units $A(x)$

48. Skip

49. Horizontal stretch by 2, up 3 units $C(x)$

Chapter 3 Review

- 1a. $f(x) = x^3$

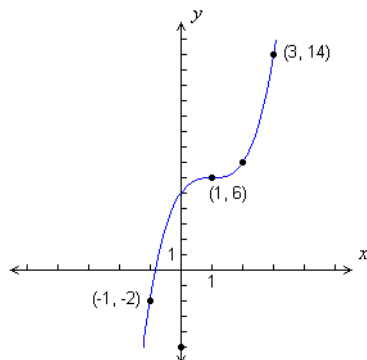


- b. $g(x) = f(x-1) + 6$

$g(x)$ is $f(x)$ shifted right 1 and up 6

$$(x, y) \rightarrow (x+1, y+6)$$

- c and d.



- e. $g(x) = (x-1)^3 + 6$

19a.

Year (since 1992)	Median Family Income in Constant (2003) dollars
-12	44,452
-7	45,223
-2	48,248
0	46,992
2	47,615
4	49,378
6	52,675
8	54,191

b. Left 1992 years or $t = y - 1992$

c. $g(x) = f(x+12)$

21a.

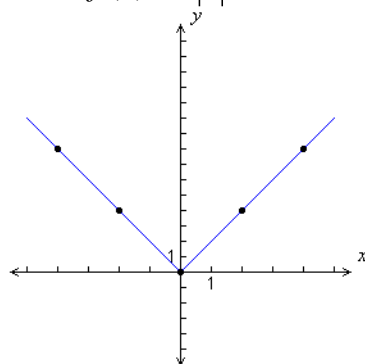
Year	Median Family Income in Constant (2003) dollars
1980	0
1985	771
1990	3796
1992	2540
1994	3163
1996	4926
1998	8223
2000	9739

b. Median Family Income minus the 1980 amount of \$44,452

c. $g(x) = f(x) - 44452$

34a.

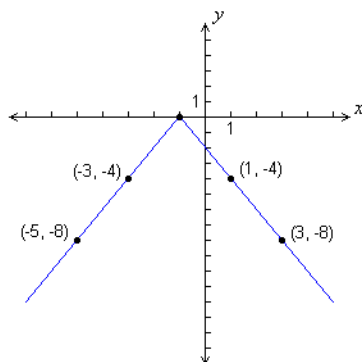
$f(x) = 2|x|$



b. $g(x) = -f(x+1)$

 $g(x)$ is $f(x)$ reflected over the x -axis and shifted left 1 unit

c and d.



e. $g(x) = -2|x+1|$

46.

x	$f(x)$	$\frac{1}{2}f(x)$	$4f(-x)$	$-2f(x-3)$
-9	2	1	0	unknown
-6	4	2	4	-4
-3	7	3.5	20	-8
0	11	5.5	44	-14
3	5	2.5	28	-22
6	1	0.5	16	-10
9	0	0	8	-2

68a. $P(y)$ would shift left 2000 years. $A(y) = P(y + 2000)$

b. 1 would represent 1 decade or 10 years, 1 would represent 2 decades or 20 years, so the horizontal compression is by a factor of $\frac{1}{10}$.

$$N(x) = P(10y)$$

c. $M(x) = 1,000,000P(10x + 2000)$

M models the population of the U.S. in x decades after 2000